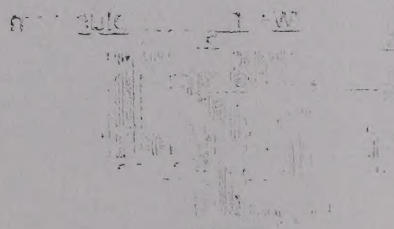
Copley Controls Corp.
375 Elliot Street Newton, Massachusetts 02164
Telephone 617-965-2410

# DC POWER AMPLIFIER MODULES

## MODEL 220-10

## MODEL 230-10



MP MASTER
MA34341

5/15/86

## INTRODUCTION

Copley Controls Corp. has designed MOSFET switching type, high efficiency, high power amplifiers that are being used in many diverse applications such as:

Electromagnetic beam positioning
Permanent magnet shake tables
4-Quadrant programmable power sources
Dynamometer test stands
CAT scan systems
NMR Gradient supplies

The Models 220 and 230, which are the root products were first developed as servo amplifiers for use driving high power DC torque motors, and are currently being used in those servo applications where high power, wide bandwidth, and low noise is a design consideration. Soon after the introduction of these products and technical coverage by the trade press Copley Controls was approached for many non servo applications such as those mentioned above. The product has now been engineered for suitable use in these markets. Some of the early concerns were: (1) can these "modules" be paralleled in master/slave configuration, and (2) what noise is generated by the amplifiers and to what degree will this affect system performance. On both counts the amplifier has proved suitable for these applications.

The Model 220 is rated at 75V output and can operate in 4-quadrants from supply voltages of +20V to +80V. The model 230 is rated at 150V and operates in 4-quadrants from +40V to +160V.

Copley controls is currently designing higher power models using power MOSFETS. These amplifiers are a new generation of power amplifier that will set the standard for years to come.

Please contact the factory for more detailed product and applications assistance.

# MOSFET motor controller replaces linear amplifiers

Featuring dc motor-drive outputs with less than 2% ripple, Models 220 and 230 servo amplifiers replace inefficient linear amplifiers in applications where low RFI is an important criterion. Other PWM servo amplifiers, typically switching at 5 kHz, produce a spectrum of harmonics at the amplifier/motor connection; the 220/230's 120-kHz switching frequency allows easy and effective internal filtering using low-value reactive elements.

The amplifiers drive permanent-magnet motors in either closed-loop position-controlled systems or velocity-controlled systems; therefore, they include the low-level electronics needed to process error signals from rate loops for velocity-controlled systems (or from inner loops for position-controlled applications). Operating in all four quadrants of the voltage-current plane, the controllers sink or source current bidirectionally.

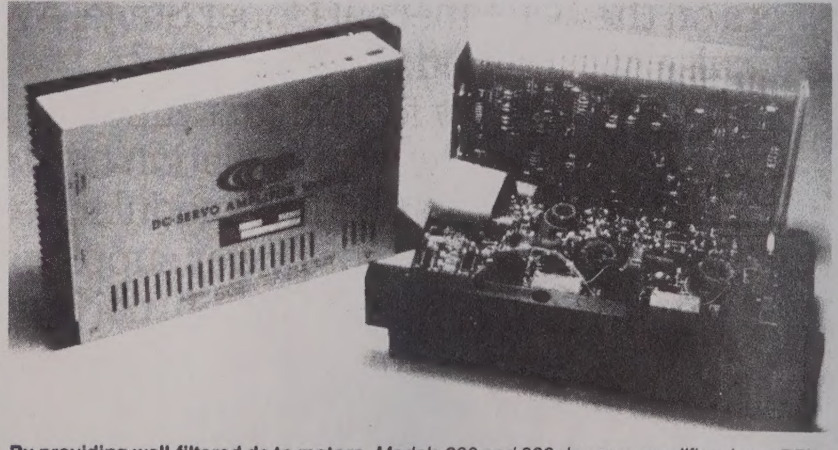
In the master/slave configuration, you can connect as many as 20 less expensive (deduct $85 from prices given) slave units to a master controller. The master synchronizes its own and all slaves' switching frequencies and controls current limiting and voltage and current feedback for all units.

Model 220 provides 0.9-kW (12A, 75V) motor drive; the 230 controls 1.5-kW (10A, 150V) drive. Peak currents (2 sec) for the two controllers are 18A and 15A, respectively. With 20 slaves connected to a master, 220- and 230-based systems handle 18.9 and 31.5 kW, respectively. The amplifiers require ±15V supplies for their internal circuitry and output-stage supplies of 20 to 80V and 40 to 170V, respectively.

The controllers are packaged in 7.8×12.9×2.25-in. metal-sheathed modules; they're available with ($40 extra) or without finned heat sinks. With the heat sink, the units deliver full power at 50°C max ambient temperature; without the heat sink, mounting to a 60°C max flat machined surface allows full-power operation. The 220 and 230 are $1100 and $1310.—***Bill Travis***

*Copley Controls Corp, 375 Elliot St, Newton, MA 02164. Phone (617) 965-2410.*

**Circle No 739**



**By providing well-filtered dc to motors,** *Models 220 and 230 dc servo amplifiers keep RFI to a minimum in sensitive environments. Handling 0.9 and 1.5 kW, respectively, they're amenable to cascading in master/slave configurations to provide drives as high as 18.9 and 31.5 kW. The amplifiers are available with or without finned heat sinks.*

# PWM amp vies with high-power linears

***Phone-book-sized amplifier rated at over 1 kW has 80-kHz switching frequency***

A pulse-width-modulated amplifier rated at 1.1 kW continuous and 1.6 kW peak at 75 V boasts 10 times the bandwidth and more than 3 times the switching frequency of other PWM amps. Its linearity also outdoes theirs by an order of magnitude.

To be more specific, the model 220-10 from Copley Controls has a dc to 10-kHz bandwidth and an 80-kHz switching frequency, which beat the 800 Hz to 1-kHz bandwidth and 15 to 20-kHz switching frequency of other PWM amps. Its linearity is 0.05% from dc to 700 Hz and below 1% from 700 Hz all the way up to 10 kHz.

All this performance fits inside a box measuring just 7.7 (L) x 12.9 (W) x 2.25 (H) in. The unit dissipates only 84 W at full load for 92% operating efficiency. It is therefore half the size of, yet twice as efficient as, linear amps with comparable output.

Up to now, the linear type has been the only way to go for designers of vibratory tables, motion control systems, function generators, and nuclear magnetic resonance systems (see *box*, "An NMR System on Wheels"). But the linear amps' wide bandwidth and low distortion come at the expense of large size and inefficiency. Linear amps are usually housed in free-standing racks equipped with bulky water coolers for dissipating heat.

The model 220-10 offers a useful alternative. Although it still lacks the 20-kHz or so bandwidth of the best-performing linears, its distortion characteristics approach theirs. More important, it offers the size and efficiency advantages of PWM amplifiers. The model 220-10 can be built directly into a piece of equipment and needs no added cooling.

A patented MOSFET H-bridge output circuit is responsible for the 220-10's low distortion and efficient power handling. The circuit eliminates the crossover distortion common in other PWM amps. It also lets the amp attain its 80-kHz switching frequency because it uses MOSFETs with very low on-resistance in conjunction with internal driver circuitry that minimizes switching losses at high frequencies. And the 80-kHz figure in turn minimizes the size of the internal filter needed to smooth the output pulse into a replica of the amp's square-wave input.

The user can parallel as many as 20 model 220-10s in a master-slave configuration for a higher power output—up to 30 kW continuous and 48 kW peak at 75 V.

Two versions of the model 220-10 are available. The master 220M-10 contains the circuitry to condition the analog input signal into a square-wave pulse. The slave 220S-10 can only accept the preconditioned square-wave pulse from the master amplifier.

In quantities of 1 through 9, the 220S-10 lists for $975, the 220M-10 for $1,060. Delivery for both is 4 to 6 weeks ARO.

For more information, call Barry Friedman of Copley Controls Corp., Newton, MA, at (617) 965-2410, or circle 314.

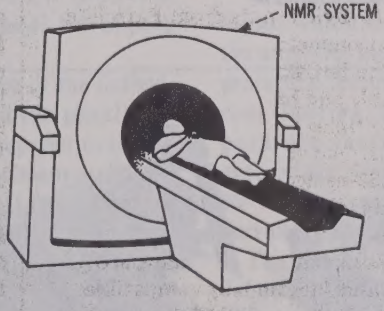
*—Spencer Chin*

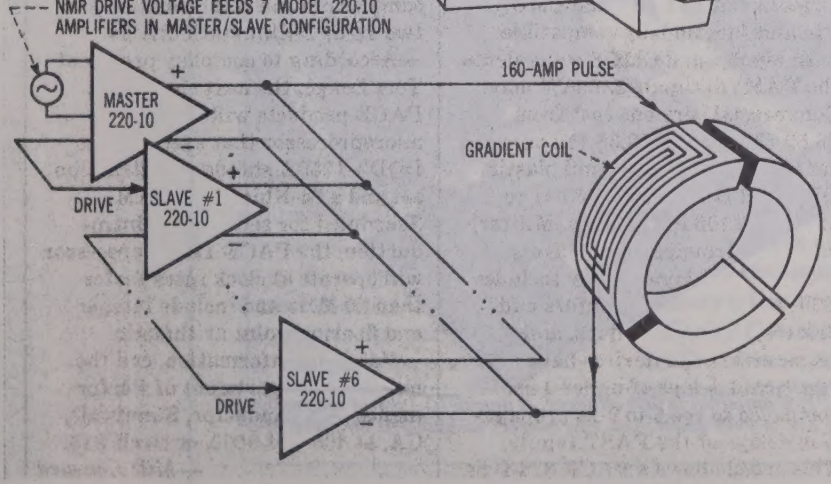
### An NMR system on wheels

To dodge the risks of X rays, some hospitals resort to nuclear magnetic resonance (NMR) systems in order to obtain images of their patients' internal organs. In an NMR system, a series of gradient coils driven by wideband power amplifiers generates magnetic patterns that depict a region of the patient's body.

In the past, only linear amps have met the wide bandwidth requirements of NMR. But these amps are so large and inefficient that the NMR system has had to be housed in a special room to which the patients have to be transported.

Copley Controls' phone-book-sized PWM amp has changed that for Diasonics of South San Francisco. In its newest NMR system the company uses seven 220-10s to control 160-A gradient coils. As a result, the system is small enough to be rolled right up to the patient.



# PWM kilowatt dc amplifier allows slaving to 30 kW

A modular, dc-coupled amplifier that measures 7.7×12.9×2.25 in. delivers 1.1 kW of continuous power (±15A at ±75V) and 1.6 kW of peak power. Model 220-10 uses pulse-width modulation (PWM) and a bridge-connected power-MOSFET output stage to hold internal dissipation down to 84W at full load. The unit's power efficiency is thus 92%.

You can connect amplifiers in parallel in a master/slave configuration to deliver 30 kW of continuous output (±450A at ±75V) or 48 kW peak. The amplifier's high (80-kHz) PWM switching rate is responsible for the unit's 10-kHz frequency response; this high switching frequency also simplifies the design (and reduces the size) of the internal filter needed to smooth the 80-kHz output pulses into an amplified replica of the amplifier's input. The 80-kHz output ripple is less than 1% at full load.

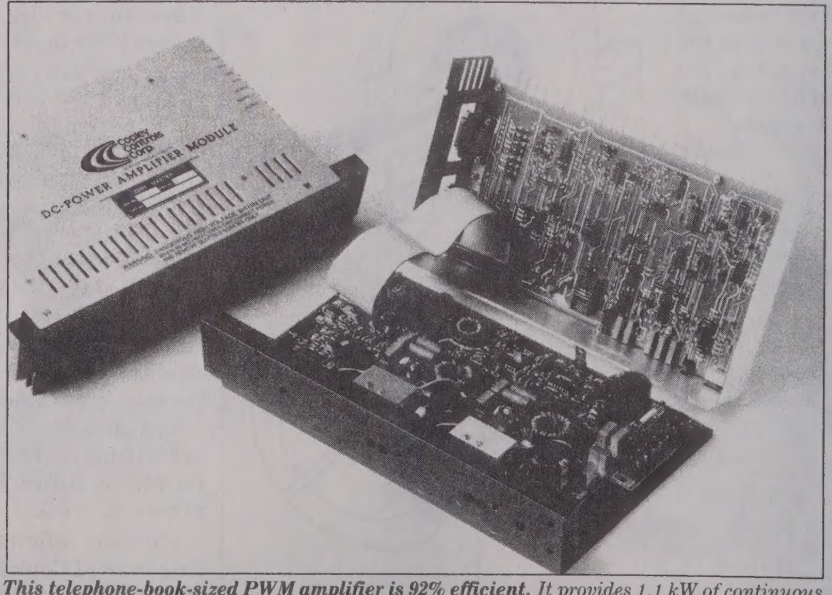
The output's power-MOSFET bridge uses a proprietary circuit that eliminates the crossover deadband inherent in many PWM amplifiers. Eliminating this deadband results in low distortion specs: 0.05% linearity from dc to 700 Hz and 1% total harmonic distortion from dc to 10 kHz.

Because of its high efficiency, the amplifier can operate over 0 to 60°C with no power derating. Built-in fault-detection/protection circuitry protects the amplifier against damage from overloads, short circuits, or excessive temperature rise.

Model 220M-10, the master unit, costs $1060 and can control as many as 30 slaves. Slave unit 220S-10 costs $975.—***Bill Travis***

*Copley Controls Corp, 375 Elliot St, Newton, MA 02164. Phone (617) 965-2410.*

**Circle No 736**

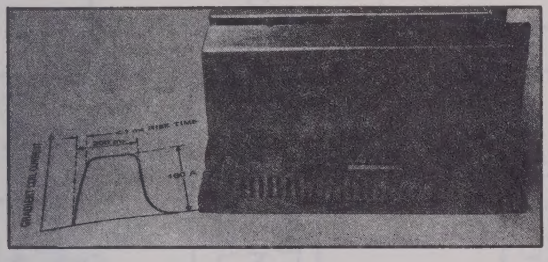



***This telephone-book-sized PWM amplifier is 92% efficient.*** *It provides 1.1 kW of continuous output power. To obtain 30 kW of load power, you can connect as many as 30 units in a master/slave configuration.*

POWER

ELECTRONIC DESIGN EXCLUSIVE

# Kilowatt dc amplifier runs at 92% efficiency



Capable of continuously putting out 1.1 kW in the band between dc and 5000 Hz, the Model 220-10 amplifier dissipates just 84 W when driving a 15-A load with 75 V. With its 92% efficiency, Copley Control's module represents the most compact and efficient power source in its frequency range. Further, it can be paralleled to supply a continuous output power of 30 kW (450 A at 75 V) or as much as 48 kW of peak power.

The performance of the individual modules (and the paralleled units) is equal or superior to that of many 50% efficient linear audio amplifiers with cut-off frequencies of 10 to 20 Hz. The amplifier achieves its efficiency by pulse-width–modulating a 71-kHz carrier. Linearity error, for example, is less than 0.5% from dc to 700 Hz. Distortion is under 1% to 10 kHz, the small-signal bandwidth of the amplifier.

The basic unit can be considered a current-output device with a compliance voltage of 75 V. And it is its current output characteristic (rather than the more common voltage output) that permits the amplifier's output to be paralleled easily. Interestingly, the inputs are not exactly connected in parallel. Instead, the basic ±10 V differential input signal is applied to a so-called master. The control outputs from it are sent to a slave, and the control outputs from the slave drive the inputs of a second slave and so forth. All of the slaves have their outputs in parallel with that of the master.

In addition to a remote shutdown input, which inhibits the output, the amplifier incorporates four self-protection features: maximum current limiting, latching overtemperature shutdown (at 85°C), overvoltage shutdown if the 20-to-80-V supply exceeds 80 V, and undervoltage shutdown for all supplies.

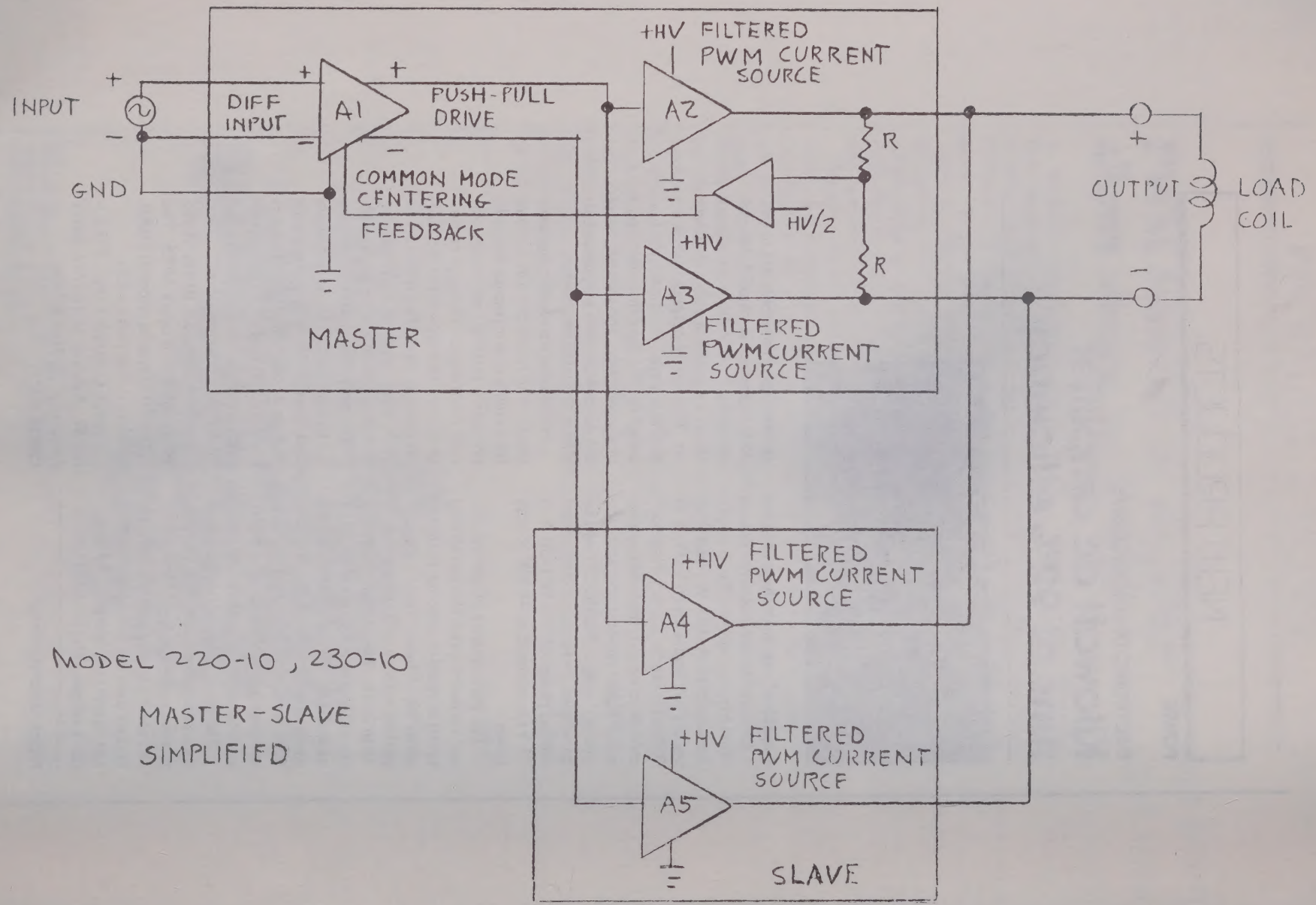
The amplifier's dimensions are 7.7 by 12.9 by 2.25 in. At maximum load, its rear mounting surface must be kept at under 60°C. The power drain is 300 and 80 mA, respectively, from the ±15 V supplies, and 22 A from a 20-to-80-V rail.

In quantities under 10, the Model 220S-10 Slave costs $975. The 220M-10 Master is priced at $1060. Delivery is four to six weeks.

*Copley Controls Corp., 375 Elliot St., Newton, MA 02164; Barry Friedman, (617) 965-2410.*

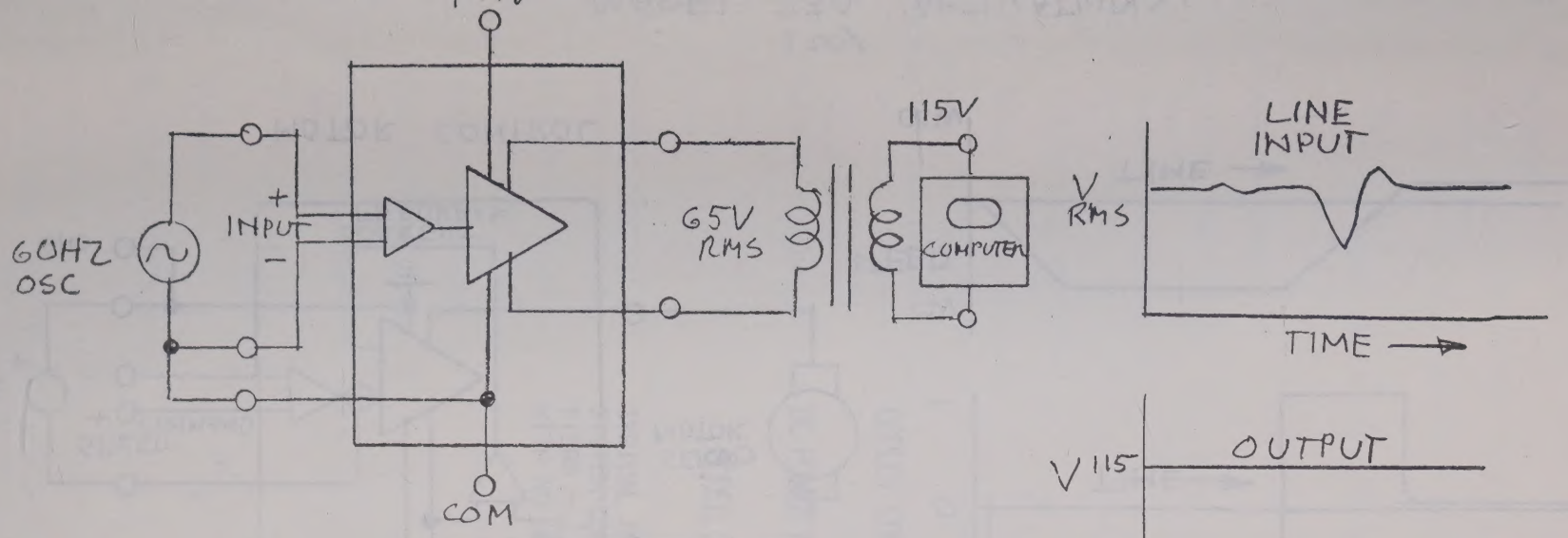
CIRCLE 303

**Frank Goodenough**

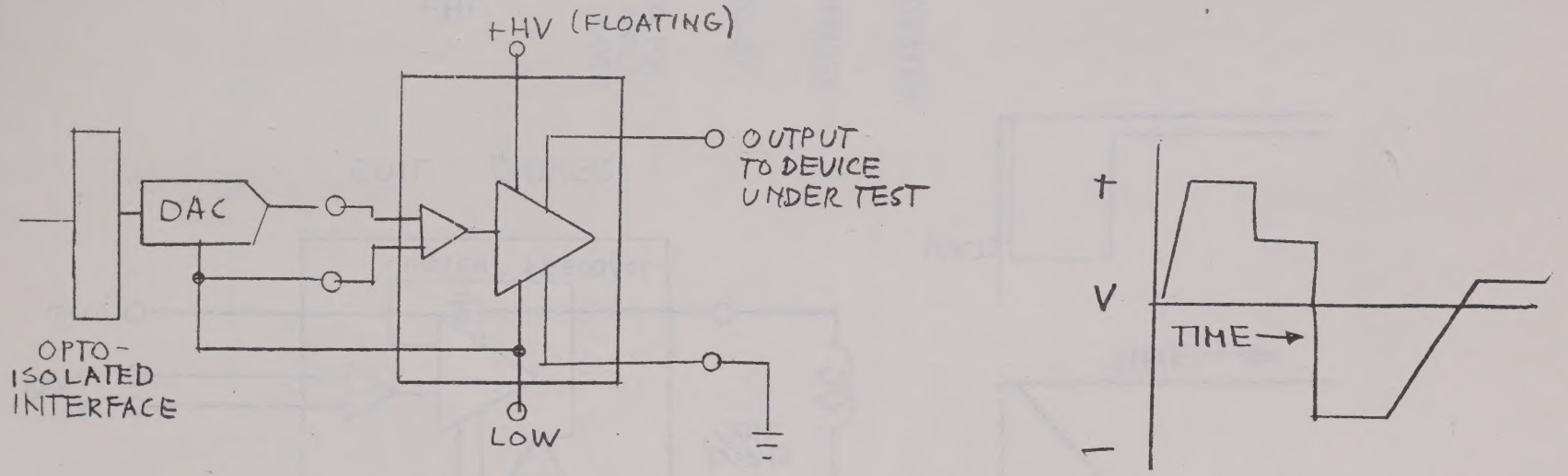



MODEL 220-10, 230-10

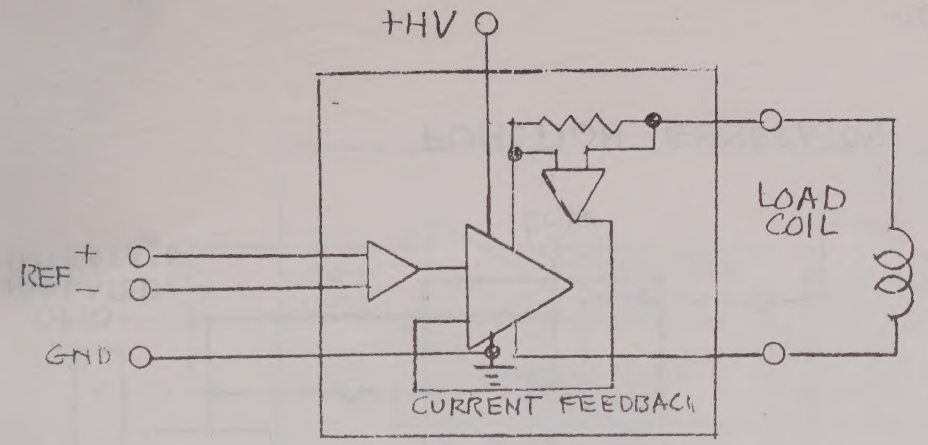
MASTER-SLAVE SIMPLIFIED



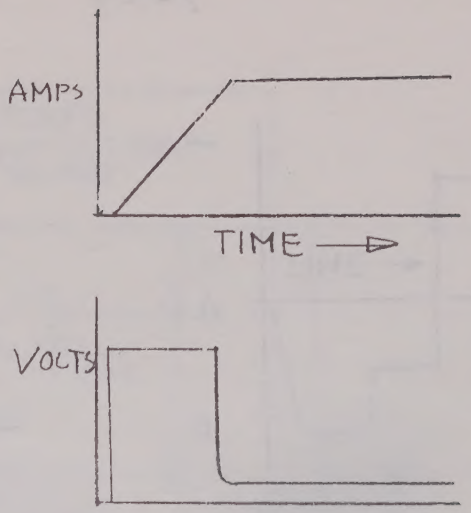

AC POWER SOURCE

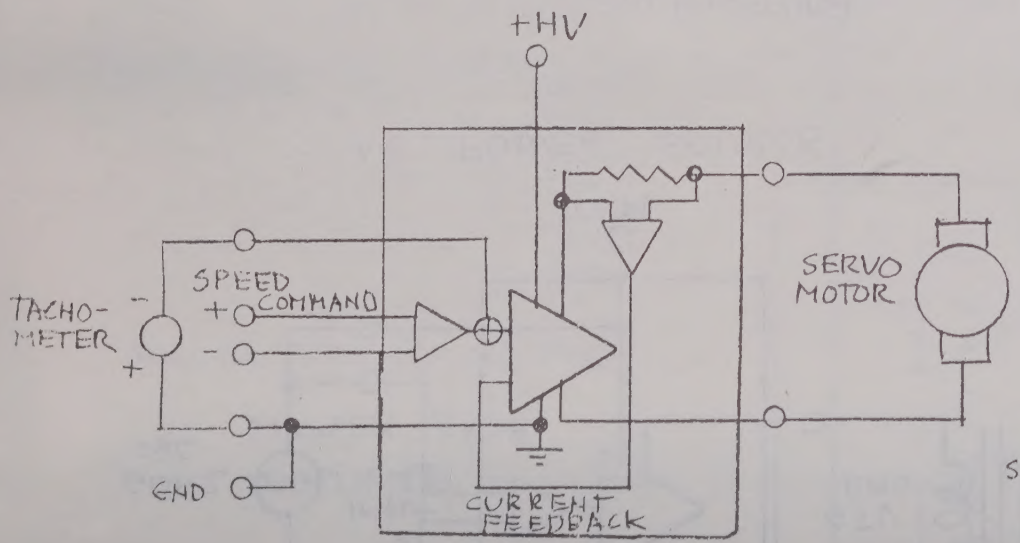



FUNCTION GENERATOR

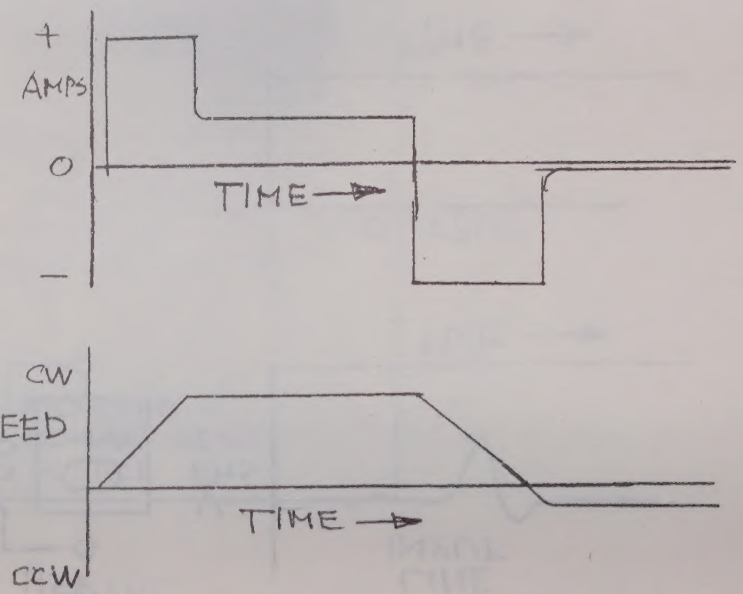



COIL DRIVER




MOTOR CONTROL



COPLEY CONTROLS CORPORATION

# DC POWER AMPLIFIER MODULES

## MODEL 220-10, 220S-10

TYPICAL SPECIFICATION FOR
SYSTEM CONTAINING 7 AMPLI-
FIERS - 1 MASTER; 6 SLAVES
WITH NO HEAT SINK

# MODEL 220-10 AND MODEL 220S-10

SPECIFICATION
(Typical specifications @ 25°C ambient, +15.0V, -15.0V, and +80V)

| | |
|---|---|
| POWER OUTPUT | ±75 V @±12A, 900W |
| PEAK RATING | |
| 100ms minimum, unidirectional | ±74V @22A , 1630W |
| 200ms minimum, bidirectional | ±74V @22A , 1630W |
| CURRENT LIMIT | .2V to 22A |
| INPUT CHARACTERISTICS | |
| Input | Differential |
| Impedance | 150 kΩ |
| Input offset | Adjustable to zero (master only) |
| GAIN | 3.7-4.5A/V, adjustable (controlled by master) |
| OUTPUT IMPEDANCE | 17Ω‖4.4μF |
| BANDWIDTH | -3db@8kHz as current source, 4 ohm load |
| SWITCHING FREQUENCY | 71kHz |
| Output ripple | 2% pk |
| PARALLEL OPERATION | Up to 20 Model 220S-04 |
| CALCULATION OF NUMBER OF UNITS; | |
| Based on total current | Peak current/22 |
| TOTAL HARMONIC DISTORTION | |
| 200Hz, $4A_{rms}$ into 4mH | 0.15% maximum |
| STABILITY | |
| Single Unit (220-10) | Stable with 2 to 6 mH shunted 0 to 0.33μF |
| Master & 6 slaves (220S-10) | Stable with 350μH to 650μH, load shunted with 0 to 2 μF. |
| SETTLING TIME | |
| 0 to ±17A | ±2% in 1.5ms |
| load: 4mH in series with 0.35Ω | ±1% in 2ms |

| | |
|---|---|
| DC DRIFT | |
| Long term(after 4-8hrs @±12A) | 2mA/°C |
| Short term (after 10 min. warm up @ ±12A) | 14mA/10 min. |
| Noise ($I_N$) Where L=load inductance (mH) | $\frac{2mA\ rms}{L\ (mH)}$ (mostly 71kHz ripple) |
| REMOTE SHUTDOWN | Switch closures inhibit output |
| AMPLIFIER PROTECTION | |
| Overload | Current limiter |
| Heatsink temperature | Latching shutdown above 85°C |
| Latchoff | Until reapplication of 15V power or depression of reset button. |
| Overvoltage shutdown | Shutdown when high voltage supply is above 92V. |
| Under voltage shutdown | Shutdown when any supply is below minimum. |
| MONITORING INPUTS | |
| Internal LED (no fault indicator) | When lit, indicates amplifier is not shutdown due to excessive heatsink temperature or improper supplies. |
| External LED (remote operation indicator) | When lit, indicates amplifier is not shutdown due to excessive heatsink temperature, or improper supplies, and additionally there is no inhibit switch closure. |
| CURRENT MONITOR | ±6V/22A each side |
| Source resistance | 2 k ohms |
| POWER REQUIREMENTS | |
| Low voltage supply | +14.3V to +16V @ 300mA<br>-14.3V to -16V @ 80mA |
| High voltage supply | +20V to +80V @22A |
| POWER SUPPLY SENSITIVITY | 4.4 mA/V |
| THERMAL REQUIREMENTS | |
| Operating | Machined flat mounting surface should not exceed 60°C for amplifier power dissipation of 84W for each Model 220 |
| Storage | -30°C to +85°C ambient |
| MECHANICAL DIMENSIONS | See outline drawing, |

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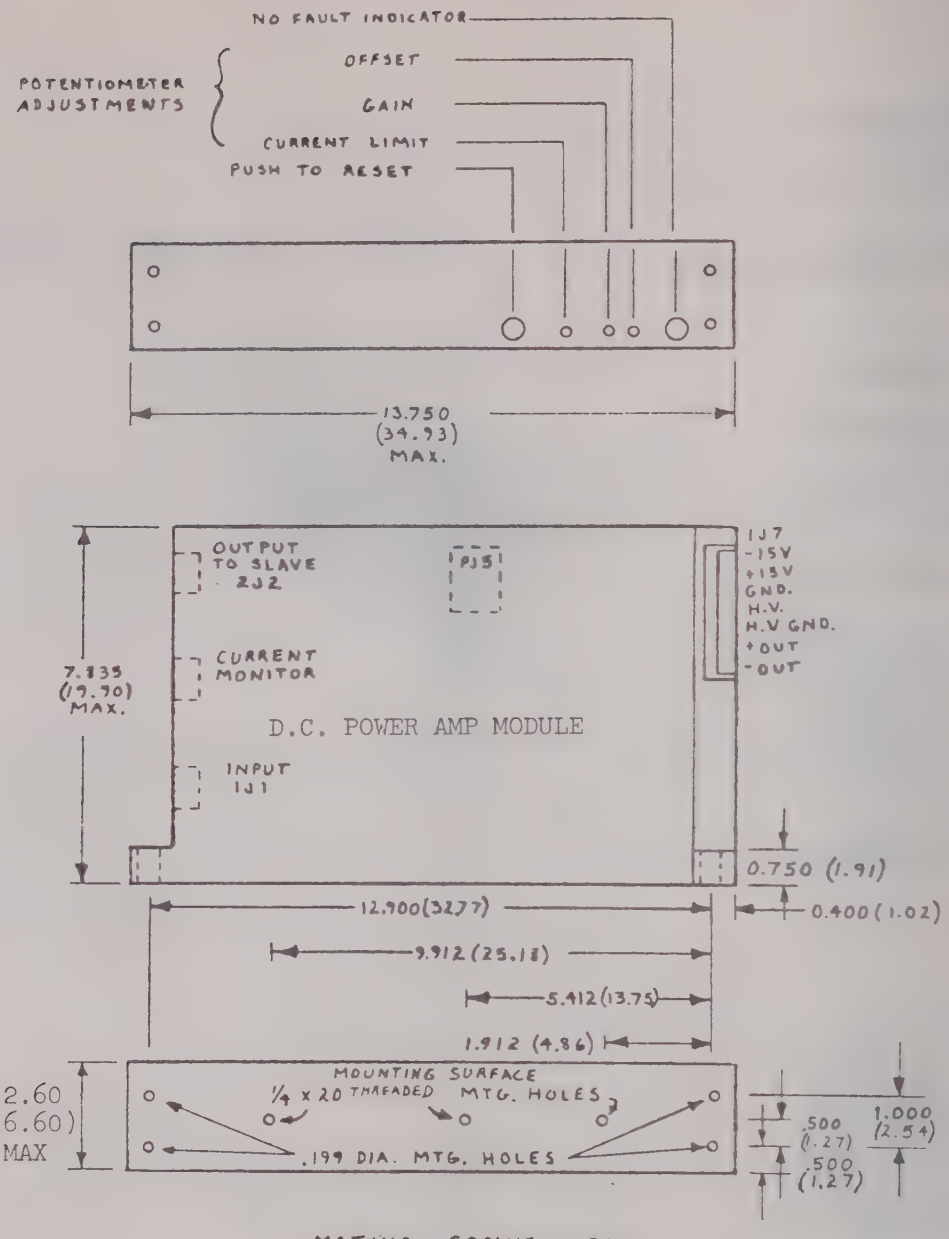
Definitions: 220-10 referred as 'master'
220S-10 referred as 'slave'

DIMENSION IN INCHES (CM.)

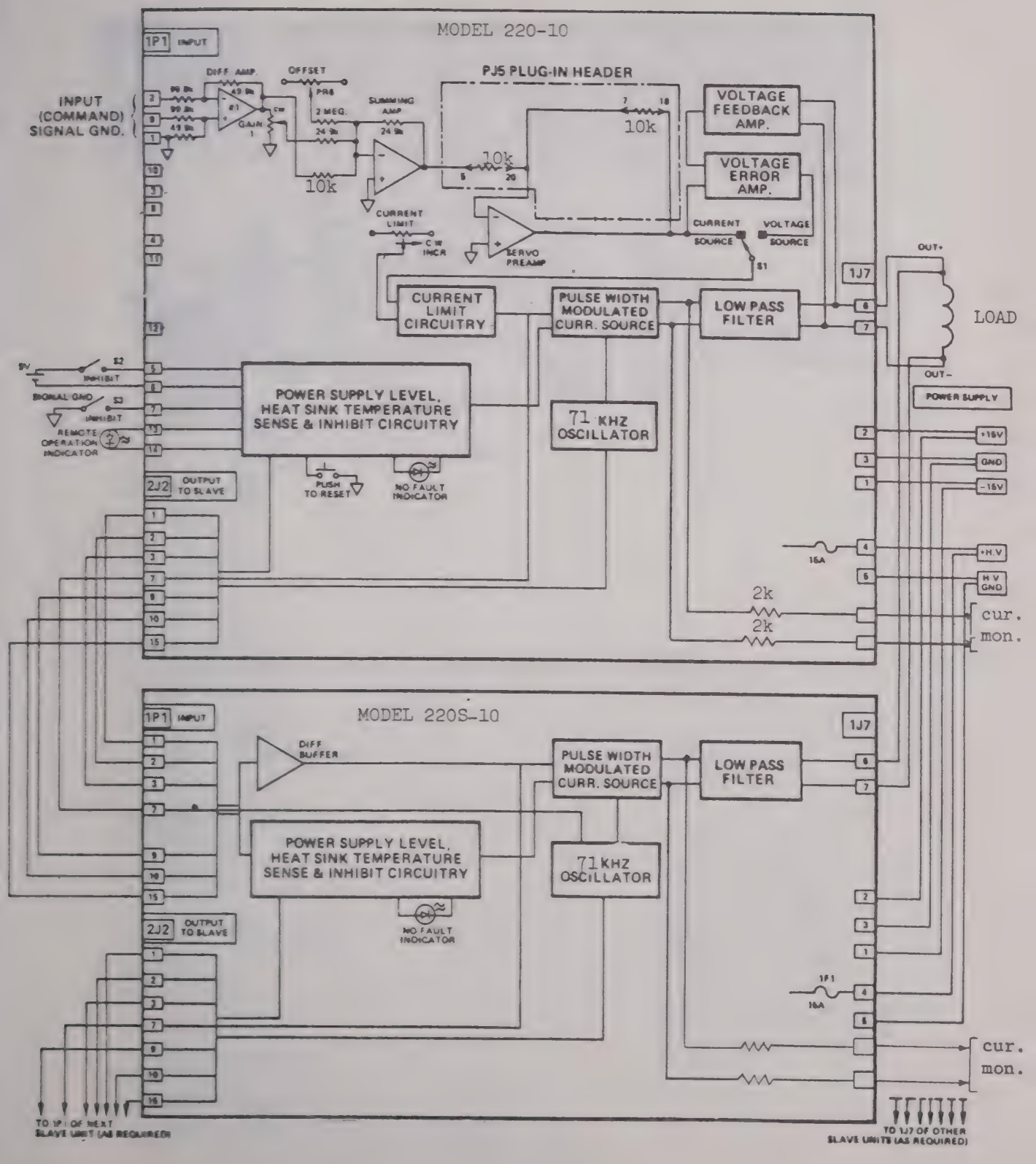


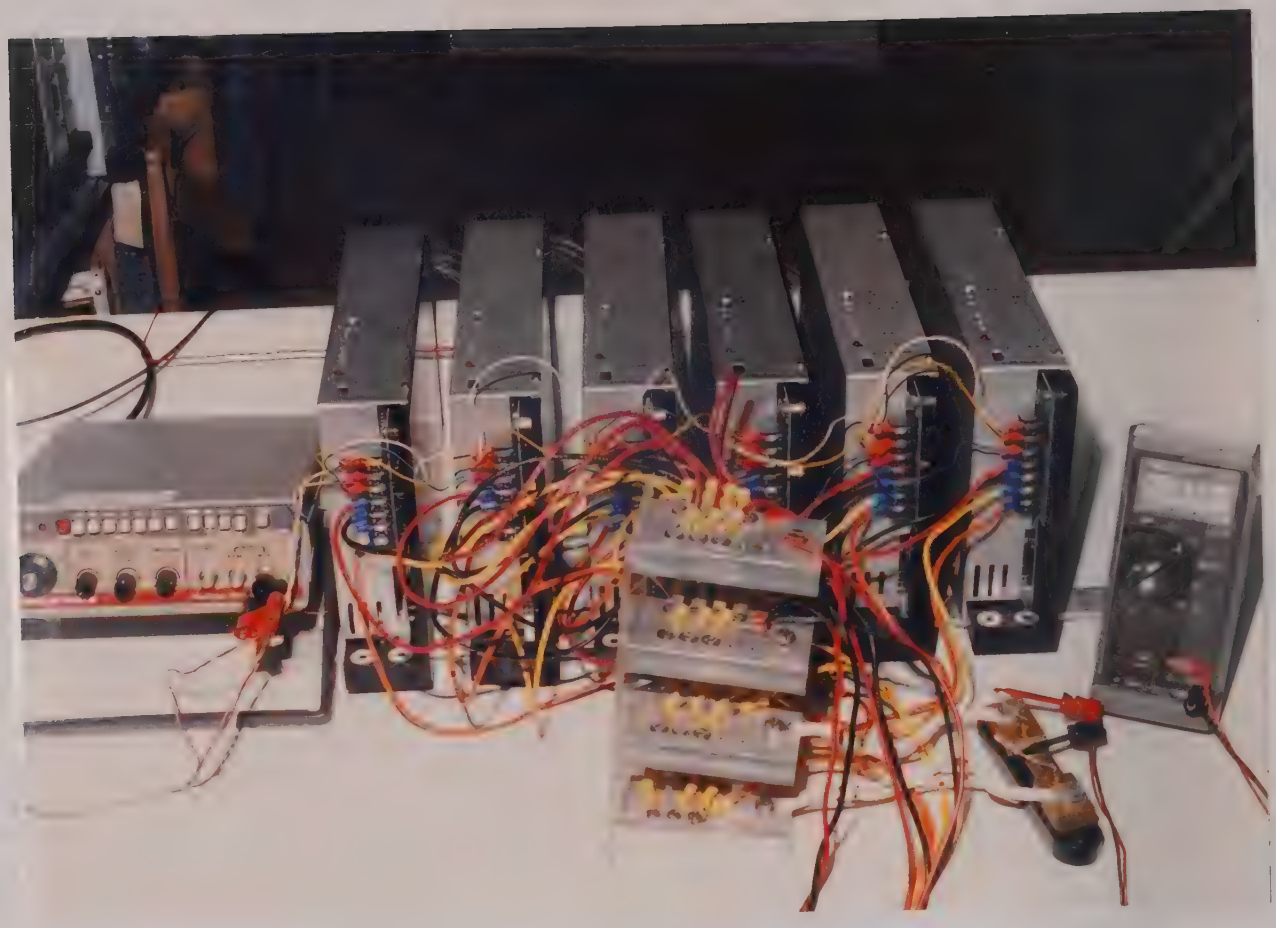

MATING CONNECTORS

1P1 15 PIN SOCKET D SUBMINIATURE
2J2 15 PIN PLUG D SUBMINIATURE
1J7 VERTICAL TERMINAL BLOCK

## OUTLINE DIMENSIONS

# FUNCTIONAL DIAGRAM





# RECORDED DATA

## 1. MASTER ALONE (220H-10), WITH HEATSINK.

| | |
|---|---|
| SUPPLY VOLTAGE | ±15V and +70V |
| Switching Frequency | 120kHz |
| LINEARITY | |
| Shorted load, amplifier zeroed | + 0.000 A |
| - input | -10.000 A |
| + input after 1 s | +10.002 A |
| after 10 s | +10.005 A |
| Test repeated when amplifier was warmer, rezeroed | + .000 A |
| | -10.002 A |
| | +10.011 A |
| SUPPLY SENSITIVITY | |
| +10 A output | +2.6mA/V |
| -10 A output | +1.555mA/V |
| This figure is a function of resistor matching and is now better in production due to the use of closer matched resistors. | |
| MAXIMUM OUTPUT CURRENT | +23,-22.9 A |
| Note: With shorted load. Due to voltage feedback the current at maximum voltage swing is 17% less. | |
| POWER DISSIPATION | |
| 100 Hz square wave into shorted load, ±23 A | 168 W |
| RIPPLE CURRENT | |
| ±23 A, shorted load | 5.13 A p-p |
| 0 A | 2.2 A p-p |
| RIPPLE VOLTAGE, @ 71 kHz | |
| 6 mH load ±23 A | -term 2.6 V p-p |
| | +term 2.5 V p-p |
| 0 A out, 6 mH load | -term 1.12 V p-p |
| | +term 1.15 V p-p |
| @80 V line, ±23 A | +term 2.9 V p-p |
| 0 A | +term 1.26 V p-p |
| GAIN | 3.77 A/V (adjustable, 30% span) |
| OUTPUT RESISTANCE | 16.128 ohms |
| CURRENT OVERSHOOT | |
| Small step, 3.6 mH, .8 ohm load | 3% |

| | |
|---|---|
| MAXIMUM HEAT SINK RISE<br>@±12A continuous output<br>Fins oriented horizontal<br>to baseplate, no forced air. | 27°C |
| COMMON MODE 120kHz<br>Signal per side @0A out | 640mV p-p<br>(T.H.D. 1% clean sine wave) |

COMMON MODE SPECTRAL DISTRIBUTION
@±12A continuous,
Load: 50 ohms
Noise measured side to ground.
Note: Switching frequency is 120kHz

| | |
|---|---|
| 60kHz | -40 DBM |
| 120kHz | +3.2 DBM |
| 180kHz | -80 DBM |
| 240kHz | -60 DBM |
| 300kHz | -120 DBM |
| 360kHz | -90 DBM |
| 420kHz | -140 DBM |
| 480kHz | -100 DBM |
| 600kHz | -150 DBM |
| 720kHz | -150 DBM |
| 840kHz | -150 DBM |

## 2. MASTER PLUS 6 SLAVES (1-220H-10, 6-220SH-10), WITH HEATSINK

| | |
|---|---|
| SUPPLY VOLTAGE | ±15V and +70V |
| Switching Frequency | 71kHz |
| MAXIMUM OUTPUT | |
| 100 Hz sq wave, shorted load | ±160 A ±5% (oscilloscope measurement) |
| DC continuous | ±92 A |

Caution: Continuous operation at ±160 A will overheat the amplifiers and cause overtemperature shutdown. Do not use the overtemperature sensor as an indicator of overload. Operate at less than ±12 A average.

| | |
|---|---|
| NOISE | |
| 6 mH load | 2mA p-p, dc-50 Hz |
| DC DRIFT | |
| -84A, shorted load | .26%/20 min after 10 min warmup |

Note: Some of this drift may be in the Empro 100 A meter shunt which became quite hot. Reversing the output polarity for 2 minutes, however, and returning to the original polarity caused the current increase of .26% to retrace to .14%.

| | | | |
|---|---|---|---|
| HV DC POWER INPUT | | | |
| +70 V, shorted load, | @ 50 A | 3.7 A | |
| | @ 70 A | 5.5 A | |
| | @ 80 A | 6.7 A | (Due only to amplifier |
| 100 Hz square wave | @ ±100 A | 9.2 A | losses and switching |
| | @ ±120 A | 11.6 A | losses; no power is in |
| | @ ±140 A | 14.5 A | the load since it is |
| | @ ±150 A | 15.5 A | a 'short.) |
| 80 V, shorted load, | @ 80 A | 6.3 A | |

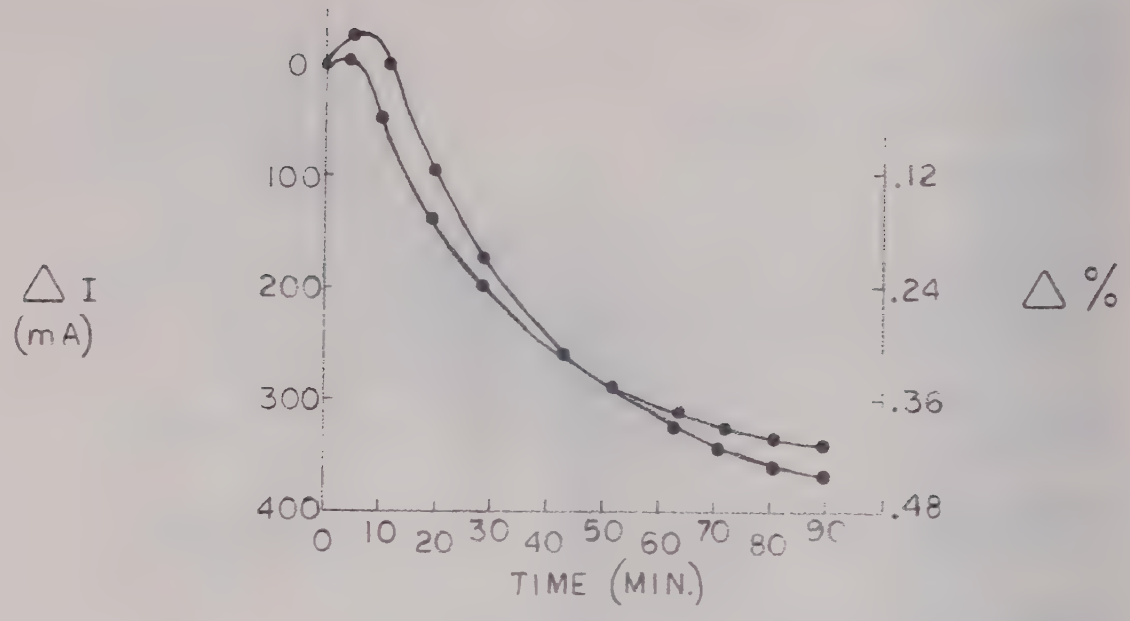
| | |
|---|---|
| RIPPLE VOLTAGE OUTPUT | |
| 6 mH load, 0 A output. Each amplifier terminal to its signal ground. | Varies over 3:1 range, 6 V p-p max |

Due to the phase locked loop the ripple of each amplifier lags the preceding one by 90°. At 71 kHz the reactance of each amplifier's output wire is comparable with the reactance of its output capacitor to ground, causing resonance. Resonance and phase shift cause this large variation in output ripple voltage as a function of the point of measurement.

| | |
|---|---|
| OVERSHOOT | |
| 500 uH load, ±10 A square wave, 20 Hz At this level the unductance of the choke is reduced. | 10% |

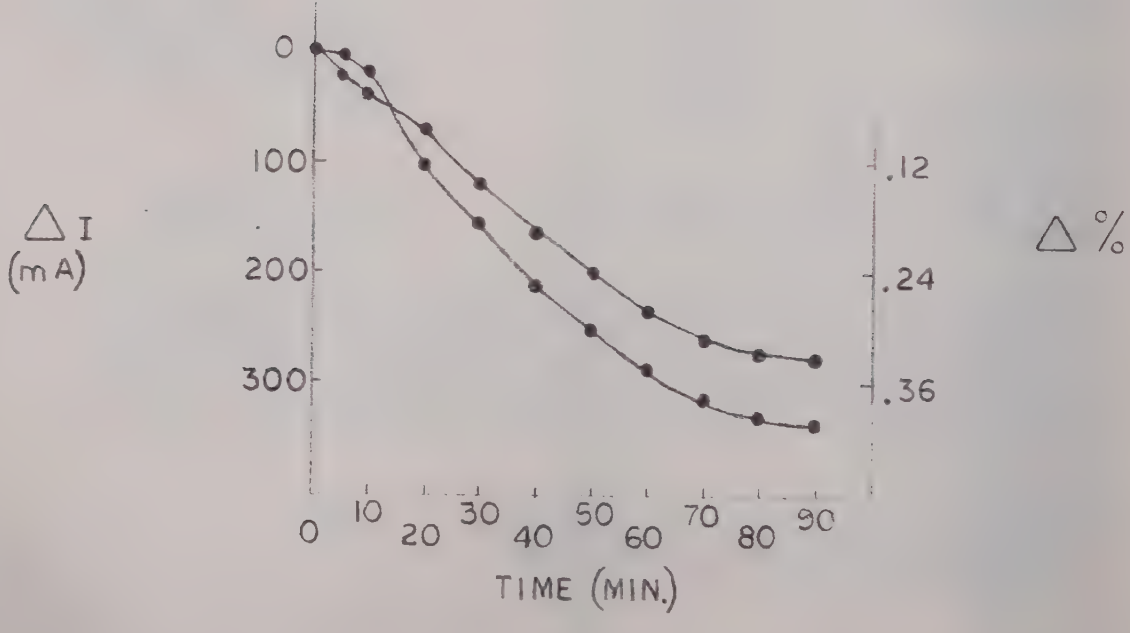
DRIFT & OFFSET

@ +84A CONTINUOUS OUTPUT

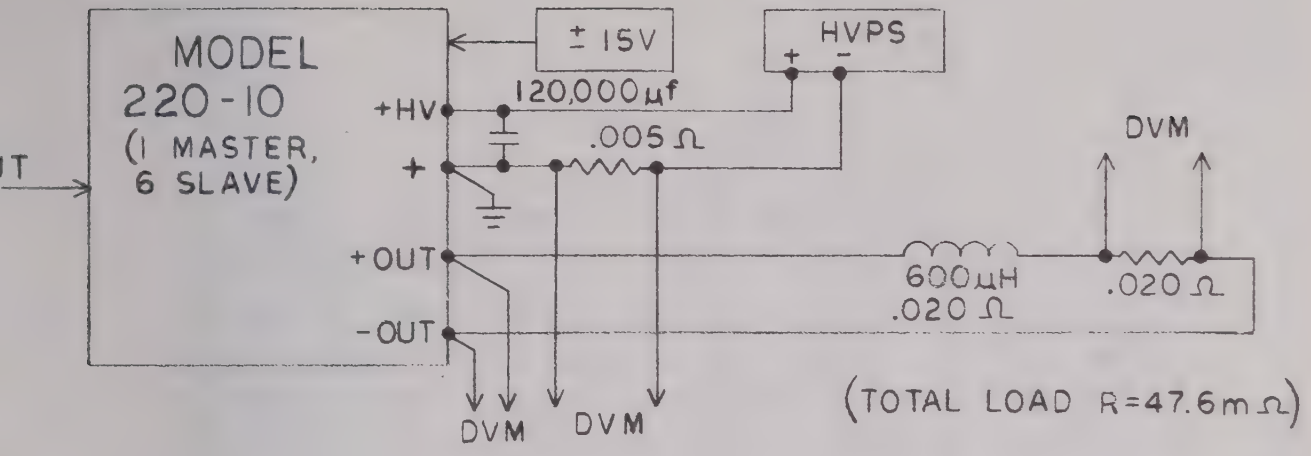



DRIFT & OFFSET

@ -84A CONTINUOUS OUTPUT



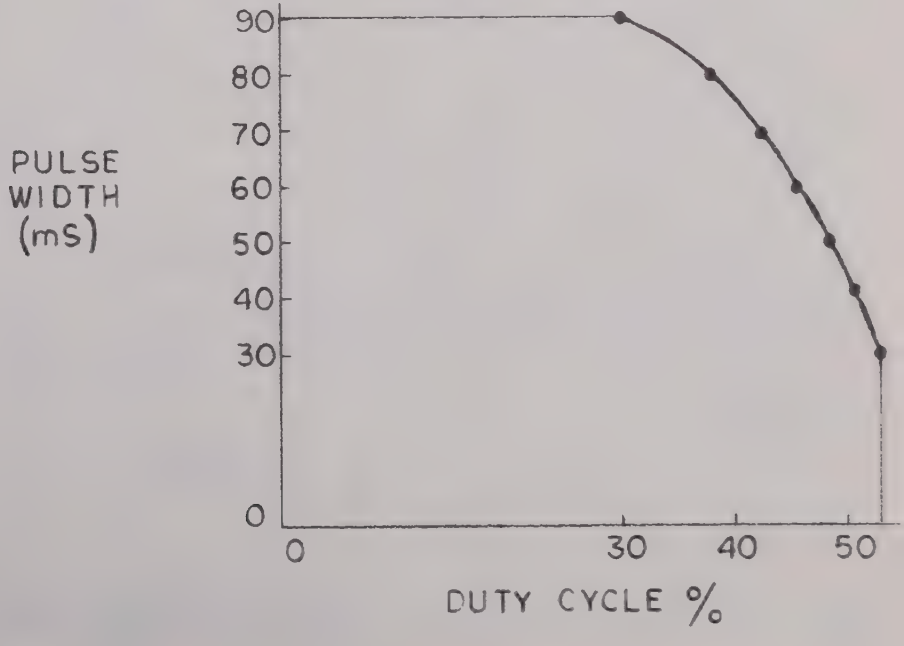
# DYNAMIC DRIFT DATA
# AND CURRENT LIMITING




FUNCTIONAL SETUP

*Shunt resistor shorted except during measurement.

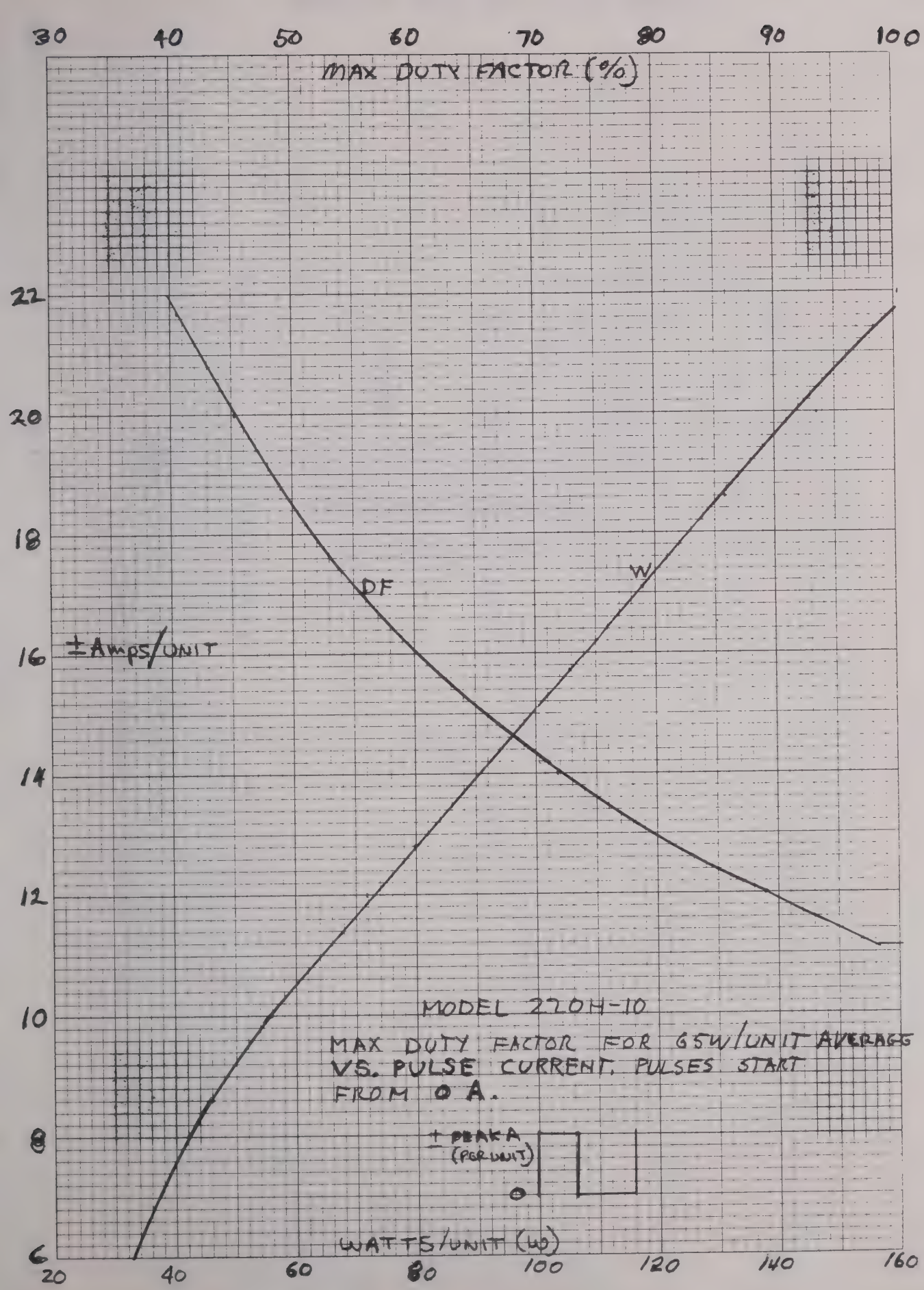
Effects of current limiter:
Continuous: +95A with +160A
pulses of various widths.
Note: Limiter prevents destruction
but may allow overtemperature
shutdown.

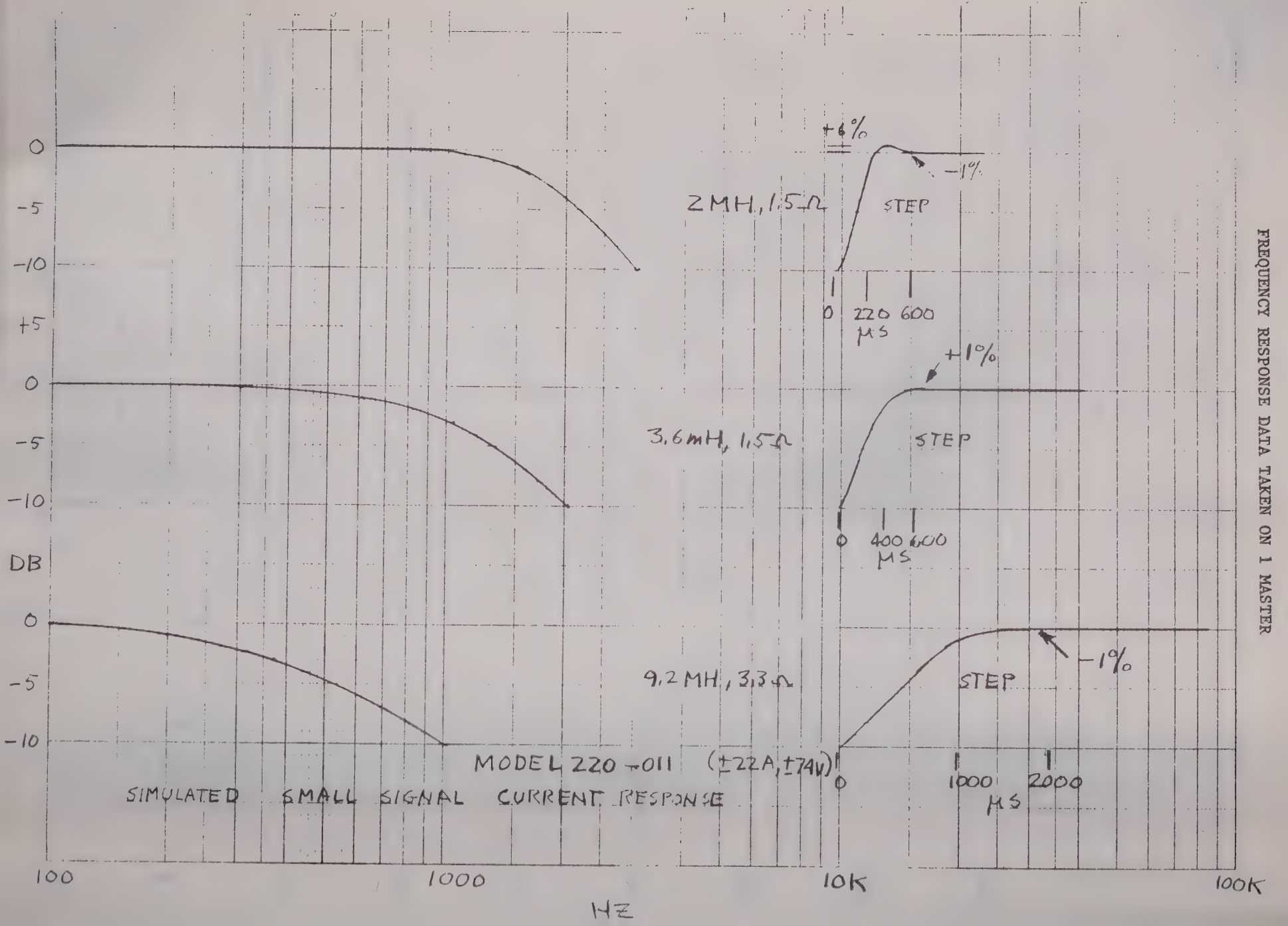


# % DISTORTION OF FOUR 220-10 AMPLIFIERS IN PARALLEL

FREQUENCY IN Hz

| CURRENT PER AMPLIFTER IN AMPS PEAK | 50 | 100 | 200 | 400 | 700 | 1000 | 2000 |
|---|---|---|---|---|---|---|---|
| 1 | .148 | .147 | .145 | .143 | .149 | .149 | .150 |
| 5 | .057 | .062 | .067 | .095 | .135 | .165 | .365 |
| 10 | .044 | .049 | .044 | .053 | .079 | .110 | .830 |
| 15 | .045 | .045 | .057 | .075 | .153 | .235 | ---- |
| 20 | .067 | .067 | .073 | .100 | .227 | .615 | ---- |


30
40
50
60
70
80
90
100
MAX DUTY FACTOR (%)
22
20
18
16
14
12
10
8
6
DF
W
±AMPS/UNIT
MODEL 220H-10
MAX DUTY FACTOR FOR 65W/UNIT AVERAGE
VS. PULSE CURRENT. PULSES START
FROM 0 A.
± PEAK A
(PER UNIT)
0
WATTS/UNIT (W)
20
40
60
80
100
120
140
160




FREQUENCY RESPONSE DATA TAKEN ON 1 MASTER

COPLEY CONTROLS CORPORATION

DC POWER AMPLIFIER MODULES

MODEL 230-10, 230S-10

# MODEL 230-10 AND MODEL 230S-10

SPECIFICATIONS
(Typical specifications @25°C ambient +15.0 V, -15.0 V, and 160 V

| | |
|---|---|
| POWER OUTPUT | ±154V @±10A, 1540W |
| PEAK RATING | |
| 100ms minimum, unidirectional | 152V @15A |
| 200 ms minimum, bidirectional | 152V @15A |
| CURRENT LIMIT | 1.5A to 15A |
| INPUT CHARACTERISTICS | |
| Input | Differential |
| Impedance | 150KΩ |
| Input offset | Adjustable to zero (master only) |
| GAIN | 1-1.8A/V, adjustable (controlled by master) |
| OUTPUT IMPEDANCE | 50Ω‖4μF |
| BANDWIDTH | -3db@8kHz as current source, 10 ohm load |
| SWITCHING FREQUENCY | 71kHz |
| Output ripple | 2% pk |
| PARALLEL OPERATION | Up to 20 Model 230S-10 |
| CALCULATION OF NUMBER OF UNITS; | |
| Based on total current | Peak current/15 |
| TOTAL HARMONIC DISTORTION | |
| 200Hz, $2.7_{rms}$ into 4mH | 0.15% maximum |
| STABILITY | |
| Single Unit (230-10) | Stable with 2 to 30 mH shunted 0 to 0.33μF |
| Master & 10 slaves (230S-10) | Stable with 200μH to 3mH load shunted with 0 to 2 μF |
| SETTLING TIME | |
| 0 to ±12A | ±2% in 3ms |
| load: 20mH in series with 0.5Ω | |

| | |
|---|---|
| DC Drift | |
| Long Term (after 4-8 hrs @ ±8A | 1.4mA/°C |
| Short term (after 10 min. warm up @ ±8A | 10mA/10min. |
| NOISE ($I_N$) Where L= load inductance (mH) | $\frac{4mA\ rms}{L\ (mH)}$ (mostly 71kHz ripple) |
| REMOTE SHUTDOWN | Switch closures inhibit output |
| AMPLIFIER PROTECTION | |
| Overload | Current limiter |
| Heatsink temperature | Shutdown above 85°C |
| Latchoff | Until reapplication of 15V power or depression of reset button. |
| Overvoltage shutdown | Shutdown when high voltage supply is above 80V. |
| Undervoltage shutdown | Shutdown when any supply is below minimum. |
| MONITORING INPUTS | |
| Internal LED (no fault indicator) | When lit, indicates amplifier is not shutdown due to excessive heatsink temperature, or improper supplies. |
| External LED (remote operation indicator) | When lit, indicates amplifier is not shutdown due to excessive heatsink temperature, or improper supplies and additionally there is no inhibit switch closure. |
| CURRENT MONITOR | ±6V/15A each side |
| Source resistance | 2 k ohms |
| POWER REQUIREMENTS | |
| Low voltage supply | +14.3V to +16V @300mA<br>-14.3V to -16V @80mA |
| High voltage supply | +40 V to +170V @15A |
| POWER SUPPLY SENSITIVITY | 3mA/V |
| THERMAL REQUIREMENTS | |
| Operating | Machined flat mounting surface should not exceed 60°C for amplifier power dissipation of 84W for each Model 230. |
| Storage | -30°C to +85°C ambient |
| MECHANICAL DIMENSIONS | See outline drawing. |

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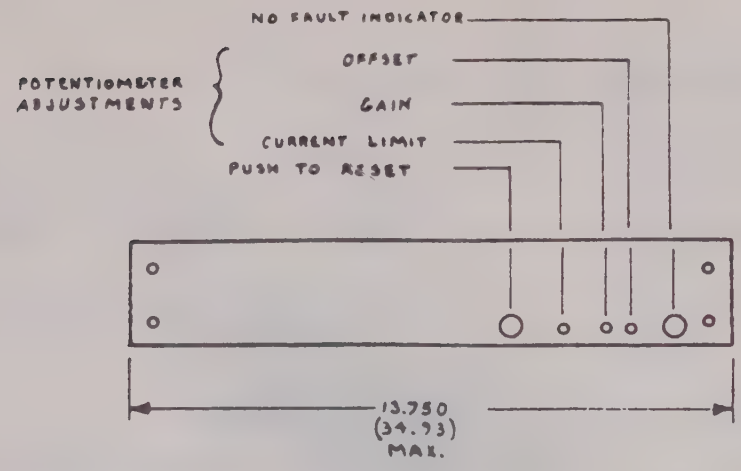
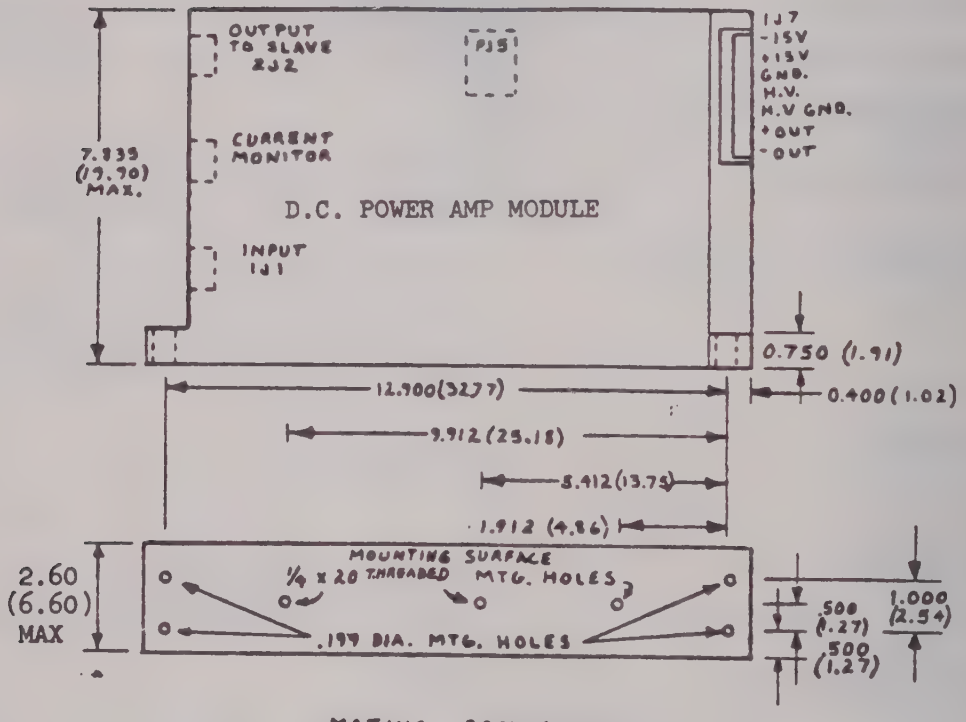
Definitions: 230-10 referred as 'master'
230S-10 referred as 'slave'

DIMENSION IN INCHES (CM.)



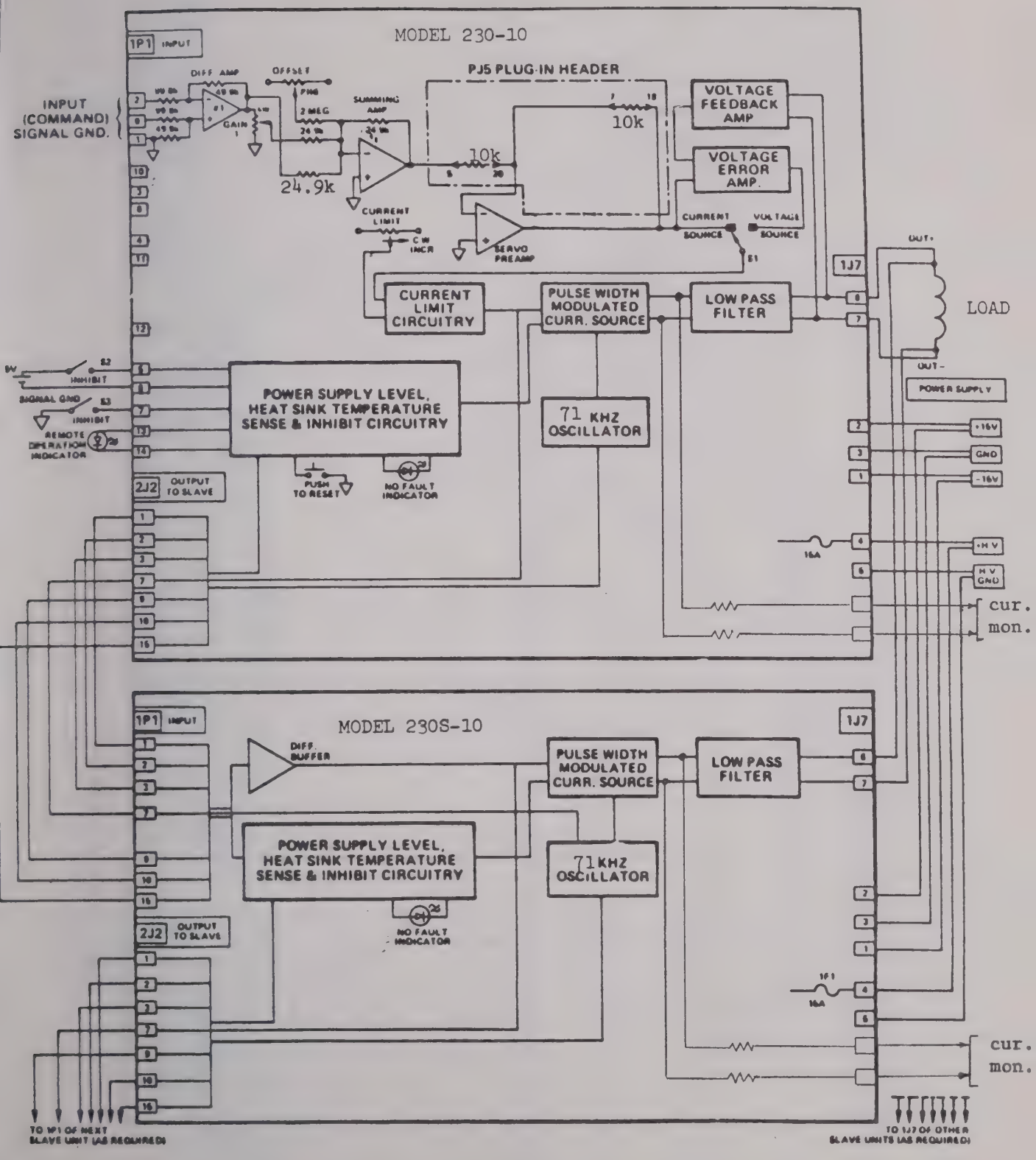



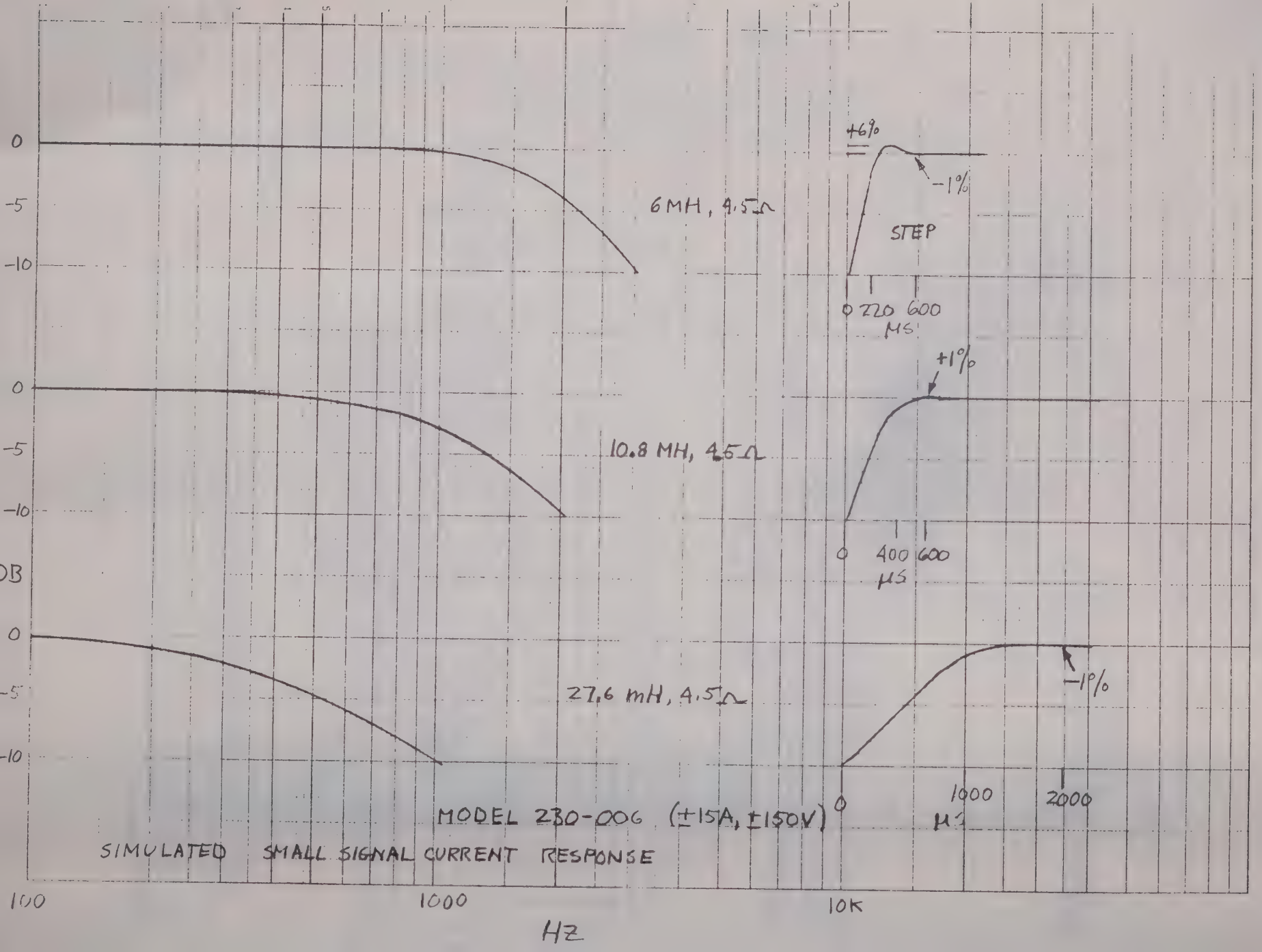

MATING CONNECTORS

1P1 15 PIN SOCKET D SUBMINIATURE
2J2 15 PIN PLUG D SUBMINIATURE
1J7 VERTICAL TERMINAL BLOCK

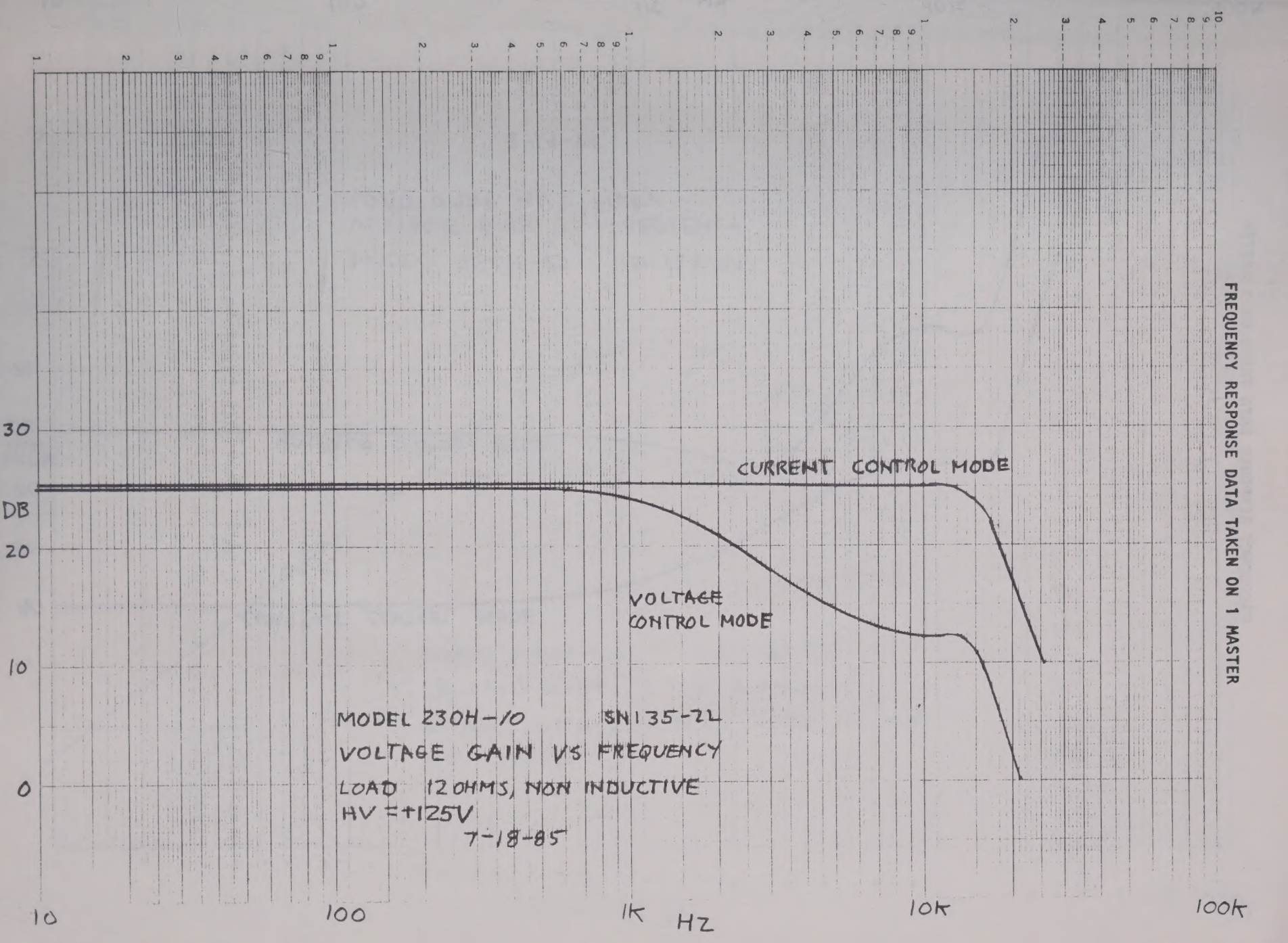
## OUTLINE DIMENSIONS

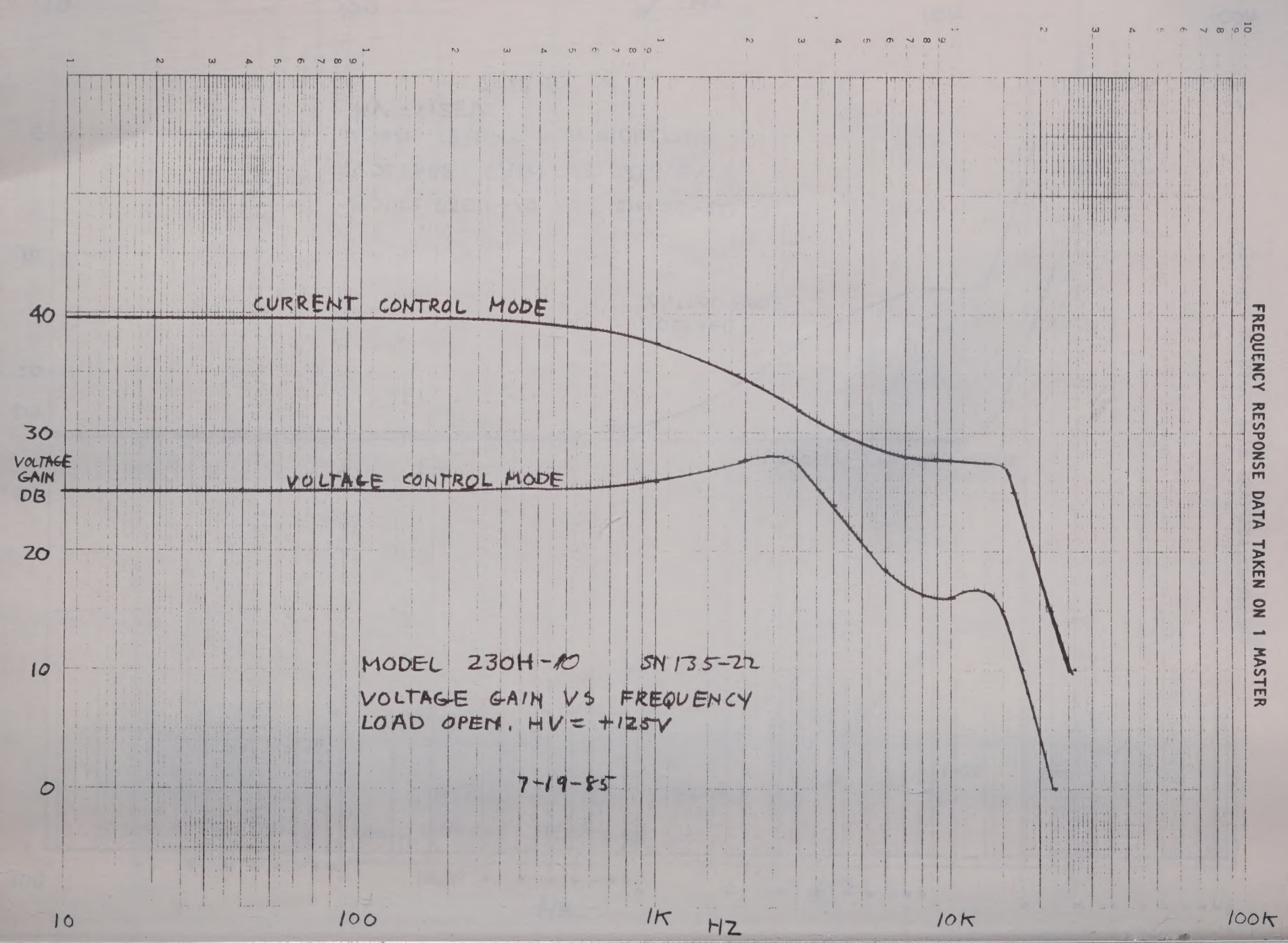
# FUNCTIONAL DIAGRAM

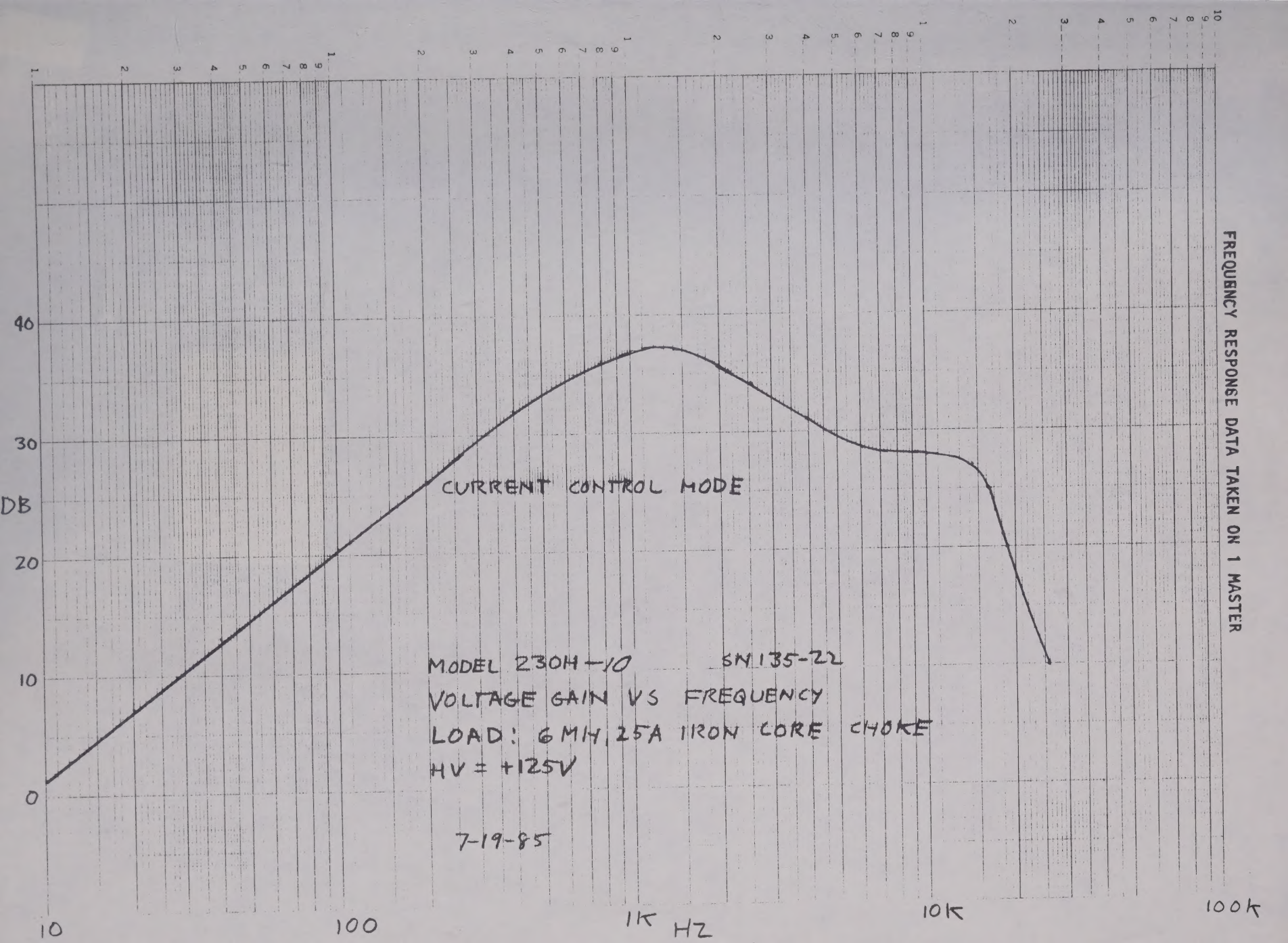





FREQUENCY RESPONSE DATA TAKEN ON 1 MASTER


FREQUENCY RESPONSE DATA TAKEN ON 1 MASTER
30
DB
20
10
0
CURRENT CONTROL MODE
VOLTAGE
CONTROL MODE
MODEL 230H-10 SN135-24
VOLTAGE GAIN VS FREQUENCY
LOAD 12 OHMS, NON INDUCTIVE
HV = +125V
7-18-85
10
100
1K
Hz
10K
100K


CURRENT CONTROL MODE
VOLTAGE CONTROL MODE
40
30
20
10
0
VOLTAGE GAIN DB
MODEL 230H-10 SN 135-22
VOLTAGE GAIN VS FREQUENCY
LOAD OPEN. HV = +125V
7-19-85
10
100
1K
HZ
10K
100K
FREQUENCY RESPONSE DATA TAKEN ON 1 MASTER


FREQUENCY RESPONSE DATA TAKEN ON 1 MASTER
CURRENT CONTROL MODE
MODEL 230H-10 SN 135-22
VOLTAGE GAIN VS FREQUENCY
LOAD: 6 MH, 25A IRON CORE CHOKE
HV = +125V
7-19-85
DB
40
30
20
10
0
10
100
1K HZ
10K
100K

MP MASTER
MA34341